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DIGITAL HIGH VOLTAGE
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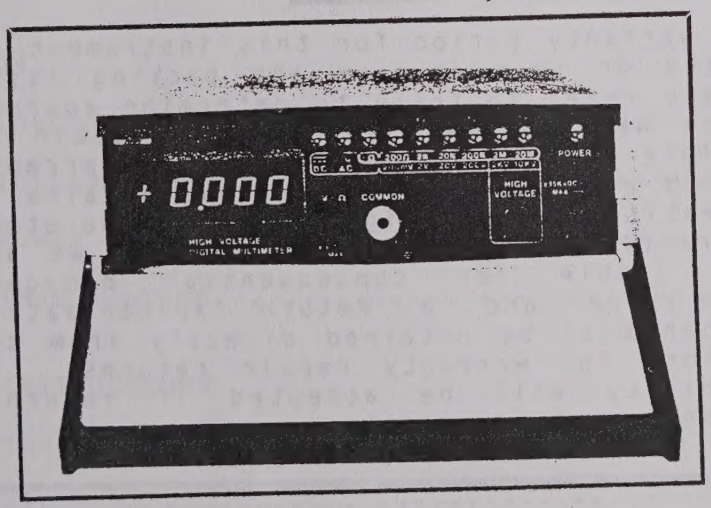
4500

DIGITAL HIGH VOLTAGE MULTIMETER

OPERATION AND MAINTENANCE MANUAL



VALHALLA SCIENTIFIC

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REV. 9-85

CERTIFICATION

Valhalla Scientific, Inc. certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. Valhalla Scientific, Inc. further certifies that its calibration measurements are traceable to the National Bureau of Standards to the extent allowed by NBS's calibration facility.

WARRANTY

The warranty period for this instrument is stated on your invoice and packing list. Please refer to these to determine appropriate warranty dates. We will repair or replace the instrument during the warranty period provided it is returned to Valhalla Scientific, Inc. freight prepaid. No other warranty is expressed or implied. We are not liable for consequential damages. Permission and a return authorization number must be obtained directly from the factory for warranty repair returns. No liability will be accepted if returned without such permission.

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MODEL 4500
HIGH VOLTAGE DIGITAL MULTIMETER
SPECIFICATIONS

DC VOLTS

Ranges:	200mV, 2, 20, 200V, 2KV, 10KV
Accuracy:	± .05% of rdg ± .025% of rng additional ± 1 ppm/V on KV ranges
Resolution:	10 microvolt on 200 mV range, 0.005% rng
Zin:	1000 Megohms on 200 mV and 2 V 100 Megohms on 2KV and 10KV 10 Megohms on 20V and 200V
NMR:	50DB at 50 or 60 Hz
CMR:	60DB AC powered, near infinity battery powered
TC:	± 0.002%/° C
Max Input:	Measures to ± 15KVDC max ± 300VDC max on lower ranges

AC VOLTS

AVERAGING CONVERTER (STANDARD)

Ranges:	200mV, 2, 20, 200V, 2KV, 10KV
Accuracy:	0.25% of rdg ± 0.25% of rng 50Hz to 20KHz 0.25% of rdg ± 0.75% of rng, 20KHz to 50KHz additional ± 1 ppm/V on KV ranges - limited to 400Hz on KV ranges.
Max Input:	15KV peak on 2KV, 10KV 300V peak all other ranges

TRUE RMS CONVERTER (OPTIONAL) (From 5% of ranges to F. S.)

Ranges:	200mV, 2, 20, 200V, 2KV, 10KV
Accuracy:	0.5% of rdg ± 0.25% of rng, 50Hz to 20KHz 1% of rdg ± 0.5% of rng, 20KHz to 50KHz additional 1 ppm/V on KV ranges - limited to 400Hz on KV ranges.
Zin:	1000 Megohm on 200MV and 2V 100 Megohm on 20KV and 10KV 10 Megohm on 20, 200V
Crest Factor:	3:1 not to exceed 150% of range
Max Input:	15KV peak on 2KV and 10KV 300V peak all other ranges

RESISTANCE

Ranges:	200 ohm	2K ohm	20K ohm	200K ohm	2M ohm	20M ohm
Test Current:	1mA	1mA	.01mA	.01mA	100nA	100nA

Accuracy:	± 0.1% of rdg ± 0.05% of rng thru 200K ohm ± 0.5% of rdg ± 0.1% rng on 2M ohm and 20M ohm range.
Resolution:	10 milliohms on 200 ohm range, 0.005% if rng
Max Input:	± 250VDC or Peak AC

SECTION I

GENERAL INFORMATION

1-1 DESCRIPTION

1-2 The Valhalla Scientific Model 4500 is a 4-1/2 digit multimeter which provides three measurement functions: DC Voltage, AC Voltage and Resistance. It is especially useful for servicing computer terminals, TV monitors and other types of CRT display equipment, since it includes a high-voltage input that permits voltage measurements to ±15KV DC and 10KV AC. It incorporates overload protection on all input ranges and functions when operated within specified limits. Although it normally operates from 115/230 VAC, an option (45B) permits operation from an internal battery supply which is rechargeable.

1-3 ACCESSORIES

1-4 The Valhalla Scientific Model 4500 is shipped with an instruction manual, a power cord and any options specified.

1-5 RECHARGEABLE BATTERY - OPTION 45B

1-6 This option consists of a 6-volt battery and a DC/DC converter. It permits up to six hours of continuous operation without recharging. The battery is on charge whenever the AC line cord is connected to the line, whether the power switch is ON or OFF.

1-7 TRUE RMS/AC CONVERTER

1-8 This option permits accurate measurements of AC voltages, whether sinusoidal or non-sinusoidal.

1-9 INPUT CABLE - OPTION C

1-10 This option is a shielded two-conductor cable which mates with the Model 4500 V-ohm input jacks and terminates in alligator clips.

1-11 HIGH VOLTAGE TEST PROBE - OPTION HVL

1-12 This option (or equivalent) is required for measurements on the 2KV and 10KV ranges. It consists of a special high-voltage cable and probe with an insulation rating compatible with the voltage rating of the instrument.

1-13 HIGH VOLTAGE PROBE - OPTION HV-2

1-14 This probe has a built-in attenuator that permits measurements to ±40KV DC or 28KV AC RMS.

1-17 1-2-4-8 DATA OUTPUTS - OPTION BCD

1-18 This option provides data outputs for driving a digital printer or a comparator such as the Valhalla Scientific Model 1248 Hi-Lo, Go No-Go, Dual Limit Comparator.

1-19 MULTI-RANGE CURRENT SHUNT - OPTION MI

1-20 This option provides six current ranges from 200 micro-amperes to 20A. It converts the Model 4500 to a direct-reading digital ammeter.

1-21 20 AMP CURRENT SHUNT - OPTION I

1-22 This option permits single-range current readings from 00.000 to 19.999 amperes.

1-23 19-INCH RACKMOUNT ADAPTOR - OPTION 45R

1-24 This option accepts the Model 4500 and adapts it for mounting in a 19-inch equipment rack. (3.5 H x 19 W x 10D)

1-25 TRMS-AVG/AC CONVERTERS

1-26 This option allows operator to choose either True RMS or Averaging AC Converter via a rear panel selector switch.

SECTION II

INSTALLATION

2-1 INTRODUCTION

2-2 This section describes initial inspection and installation of the Model 4500 Digital Multimeter.

2-3 INITIAL INSPECTION

2-4 Inspect the shipping container for signs of damage before accepting the shipment. Notify the carrier immediately if any damage is noted, either before or after unpacking the instrument.

2-5 Unpack the instrument. Retain all packing material until you have thoroughly inspected the instrument for possible shipping damage.

2-6 POWER REQUIREMENTS

2-7 The Model 4500 Digital Multimeter operates from 115/230 volt 50-60Hz power. If Option 45B is included it will also operate from an internal 6-volt battery. In battery mode, the load is absorbed by the AC line when connected to AC power and the Power switch is ON. The battery charges any time the AC line is connected, whether the Power switch is ON or OFF.

2-8 INSTALLATION

2-9 The Model 4500 dissipates little power and generates negligible heat. It may be used anywhere that the environment meets its specifications.

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SECTION III

OPERATING INSTRUCTIONS

3-1 INTRODUCTION

3-2 This section provides complete operating instructions for the Model 4500. It also includes functional descriptions of the front-panel controls.

3-3 FRONT PANEL

3-4 The Power switch is an ON-OFF pushbutton located at the extreme right-hand side of the panel.

3-5 The Function switch comprises three interlocking pushbuttons located at the panel left-center. Volts DC, Volts AC, or K Ohms is selected by pushing the corresponding button.

3-6 The Range switch comprises six interlocking pushbuttons located at panel right-center. The desired range is selected by pushing the corresponding button.

3-7 DC VOLTAGE MEASUREMENTS

3-8 Low-voltage measurements are made via the V-Ohm and Common jacks and are limited to 200 volts; voltages exceeding 200 are measured via the High Voltage and Common jacks and are limited to ±15KV DC or 10KV AC RMS. DC voltages which may exceed 200 should be measured on the 2KV range; if the actual voltage is less, the measurement may be repeated on the 200V range for maximum resolution.

3-9 HIGH VOLTAGE MEASUREMENTS

WARNING

Always use a high voltage probe with proper insulation. Avoid contact with either the Model 4500 or the high voltage source. Never touch any part of either with both hands at once. Contact with high voltage may cause injury or death.

3-10 Measure voltages expected to exceed 200 volts, via the High Voltage jack. Always use the Valhalla Scientific Option HVL (or equivalent). If the input exceeds ±15KV DC, use the Valhalla Scientific Option HV-2 40KV Probe and measure it via the V-Ohm

3-10 (Continued)
jack and common.

CAUTION

The maximum safe input at the Model 4500 High Voltage jack is ±15KV, DC or peak AC.

3-11 Always perform the following steps in exact sequence.

1. Disconnect the line power cord from the 4500, if battery operated.
2. Disconnect the line power cord from the high voltage source.
3. Set the Model 4500 Function to DC.
4. Set the Model 4500 Range to 10 KV.
5. Connect the HVL Test Probe to the Model 4500 High Voltage Jack and the Common jack.
6. Connect the probe clip to high voltage common.
7. Connect the high voltage source to the AC line and turn the power on.

WARNING

If the test clip should pull loose after power is applied to the high voltage source do not touch it before disconnecting the line cord.

8. Allow time for the high voltage source to reach full output, then touch the HVL probe tip to the high voltage terminal. If the reading is less than 2 KV remove the probe, select the 2 KV range and repeat the measurement for maximum resolution.

3-12 LOW VOLTAGE MEASUREMENTS

3-13 Use the V-Ohm and Common jacks to measure 200 volts or less. Use Option C Shielded Input Cable (or equivalent) for all low voltage and resistance measurements to prevent errors due to noise pickup.

3-14 The maximum safe input on all low voltage ranges is 300 volts. The make low voltage measurements:

1. Select the DC Function and the 200V range.
2. Connect the input cable to the unknown voltage source.
3. If the reading is less than 200 volts select the range that will give greatest resolution.

3-15 AC VOLTAGE MEASUREMENTS

3-16 Inputs less than 200 VAC rms are measured via the V-Ohm and Common jacks; maximum safe input is 300 volts peak.

3-17 High voltages are measured via the High Voltage and Common jacks and are limited to 10 KV rms. Maximum safe input is a volt-Hz product not to exceed 10^6, or 15KV peak, whichever is less. Measure voltages which may exceed 200 volts rms at the High Voltage jack. If the input is less than 200 volts repeat the measurement on the 200V range for greatest resolution.

3-18 HIGH VOLTAGE MEASUREMENTS

WARNING

Always use a high voltage probe (Valhalla HVL or equal). Avoid contact with either the Model 4500 or the high voltage source. Never touch any part of either with both hands at once. Contact with high voltage may cause injury or death.

3-19 Perform the following steps in exact sequence to measure high voltage.

1. Disconnect the line power cord from the 4500, if battery operated.
2. Disconnect the high voltage source from the AC power line.
3. Set the Model 4500 Function switch to AC and the Range to 10 KV.
4. Connect the HVL test probe to the Model 4500 High Voltage and Common jacks.
5. Connect the HVL test probe clip to the common side of the high voltage source.

WARNING

If the test probe clip should pull loose after power is applied to the high voltage source do not touch it before disconnecting the line cord of the source.

6. Connect the high voltage source to the AC line and allow time for it to reach full output.

3-19 (Continued)

7. Touch the HVL probe tip to the high voltage terminal and note the reading. If it is less than 2KV remove the high voltage probe tip from the high voltage terminal, select the 2 KV range and repeat the measurement for maximum resolution.

3-21 LOW VOLTAGE MEASUREMENTS

3-22 Inputs of less than 200 volts rms are measured via the V-Ohm and Common jacks. Use the Valhalla Scientific Shielded Input Cable (Option C). Maximum safe input voltage 300 volts peak.

3-23 To measure low voltages:

1. Select the AC Function and the 200V Range.
2. Connect the input cable to the unknown voltage.
3. Observe the reading and select the range that will yield greatest resolution.

3-24 RESISTANCE MEASUREMENTS

3-25 The maximum safe input voltage is 250 VDC or peak AC. To measure resistance:

1. Select the Ohm Function and the 20M Range.
2. Connect the unknown resistance between the V-Ohm and Common jacks via the shielded input cable (Option C) to prevent inaccurate readings due to noise pickup.
3. Observe the reading and select the range that will yield greatest resolution.

NOTE

An over-range condition is indicated by blanking all but the most significant digit. Up range until a valid indication is obtained.

SECTION IV

THEORY OF OPERATION

4-1 INTRODUCTION

4-2 The Valhalla Scientific Model 4500 Digit Multimeter is basically an A/D Converter that measures and displays DC voltages. It also includes AC/DC and OHMS/DC Converters which produce DC voltage outputs proportional to their inputs. These outputs are measured and displayed by the A/D Converter.

4-3 Model 4500 circuitry is totally solid state, using CMOS IC's extensively to minimize power consumption.

4-4 FUNCTIONAL DESCRIPTION

4-5 The following functional description is based on Figures 4-1, 4-2 and the Model 4500 schematic, Drawing Number 4500-070.

4-6 A/D CONVERTER

4-7 The Model 4500 A/D Converter incorporates a three-step integrator which provides automatic zero correction, high impedance differential inputs and automatic polarity.

4-8 The major components of the A/D Converter are a precision timer IC11, an analog processor IC12, a digital processor IC13 and a precision-voltage reference supply IC14. The analog processor contains the zero-correction circuitry, an integrator, a zero-crossing detector and the switches required to implement the integration process.

4-9 The digital processor contains an oscillator, a counter, a buffer register, an output decoder and circuitry to control the analog processor.

4-10 The three-step integration process consists of (1) sensing and storing in C14 any error voltage present in the analog circuits due to offset, noise or drift; (2) charging integrator capacitor C17 from the unknown input voltage for a fixed time; and (3) applying the reference voltage to C17 in the opposite polarity to the unknown input voltage for whatever time it takes to discharge C17 back to zero.

4-11 The greater the charge on C17 the longer it will take to discharge it to zero, and the time measured by counting the output of the oscillator in the digital processor. The oscillator frequency and the maximum integration time are chosen to produce a count exactly equal to full-range input. If the

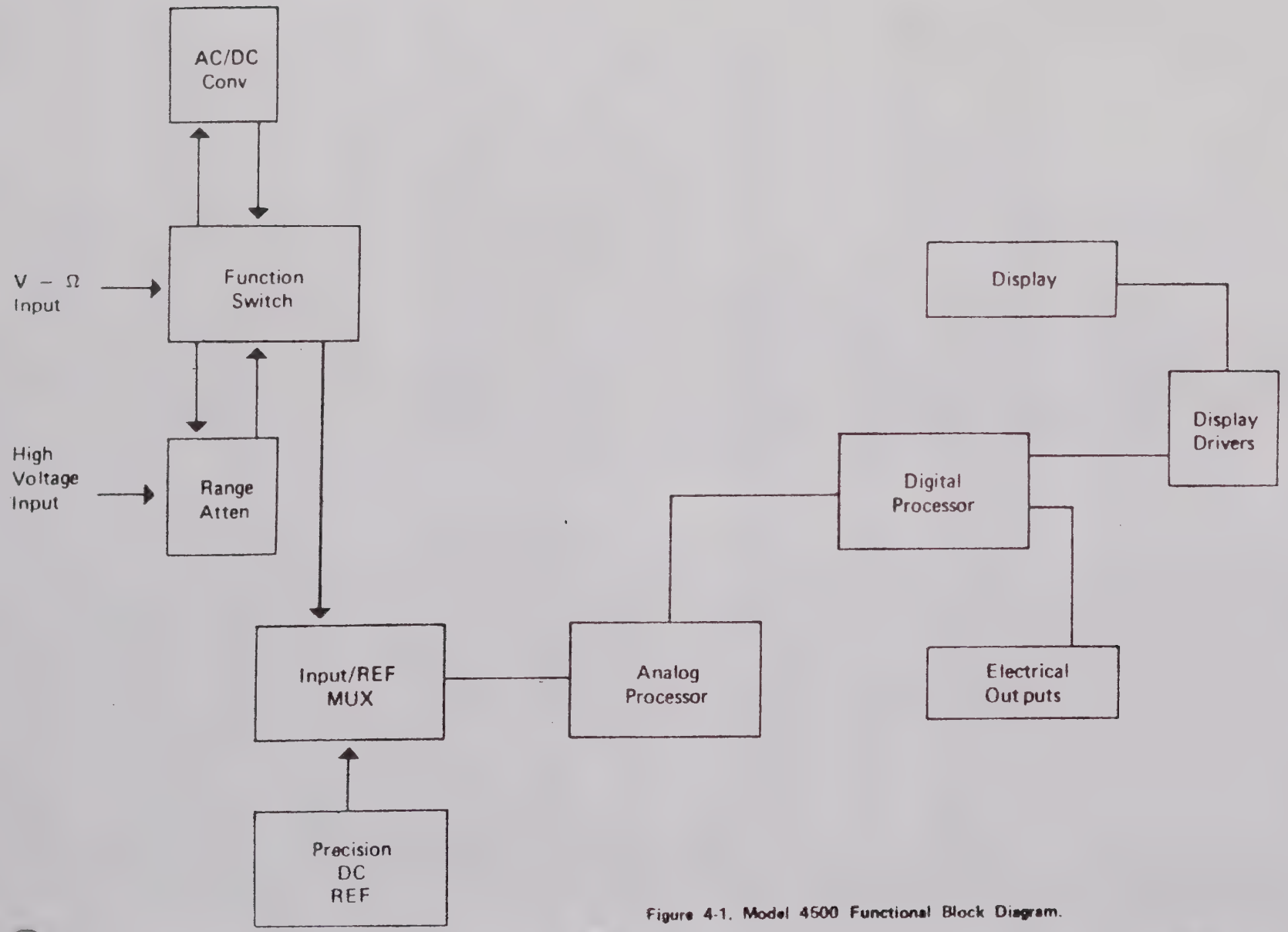


Figure 4-1. Model 4500 Functional Block Diagram.

4-11 (Continued)
unknown voltage is less than full-range input the integration time will be shorter and the count will be proportionately less.

4-12 The count is stored in the buffer register of the digital processor, and after the reference has been integrated it is shifted into the display, where it remains until the next reference integration has been completed. At that time the display is updated to again indicate the unknown input voltage.

4-13 INTEGRATOR OPERATION AND CONTROL

4-14 Time periods A and B of Figure 4-2 show two complete integration cycles; the former is for positive input, the latter for a negative input. During the first step of Period A both IC12-8 and -9 are set LOW by the digital processor, IC13. Analog inputs IC12-1 and -2 are internally disconnected from the integrator, and its input is grounded. Zero Sense capacitor C14 is charging to the value of any error voltage present in the analog circuits, and Reference capacitor C20 is charging from precision reference supply IC14 via IC12-4.

4-15 After a fixed time IC13 forces both IC12-8 and -9 HIGH and the second integration step begins. C14 and IC12-1 and -2 are connected to the integrator. The C14 charge corrects for offset while C17 charges toward the value of the unknown input voltage at a rate proportional to its amplitude. During this time the Zero-Crossing Detector output at IC12-10 goes HIGH and sets the polarity bit in the digital processor.

4-16 At the end of the fixed integration period IC13 forces IC12-8 LOW and the reference integration begins. C20 is connected to the integrator with its charge opposing the polarity of the charge on C17. The counter in IC13 is simultaneously gated ON and as C17 discharges back toward zero it counts the oscillator output in BCD format and stores it in the Buffer Register.

4-17 When the charge on C17 is reduced to zero IC12-10 drops out of its HIGH state, telling IC13 to gate the counter OFF. IC13 then forces IC12-9 LOW, returning the analog processor to the Zero Sense state. The accumulated count and the polarity are then displayed on the LED indicators until the next measurement is completed, when the display is updated.

4-18 Period B of Figure 4-2 shows timing for a negative voltage measurement. With IC12-8 and -9 LOW, C14 and C20 are charged. When IC13 forces IC12-8 and -9 HIGH the negative input is applied to the integrator input, charging C17 negative until IC13 forces IC12-9 LOW. During this time IC12-10 sets the polarity bit LOW, C20 discharges C17 back toward zero, and the oscillator output is counted. When C17 is discharged IC12-10 leaves the LOW state, the counter is gated OFF and IC12-8 is set LOW, returning IC12 to the Zero Sense state. The new count and

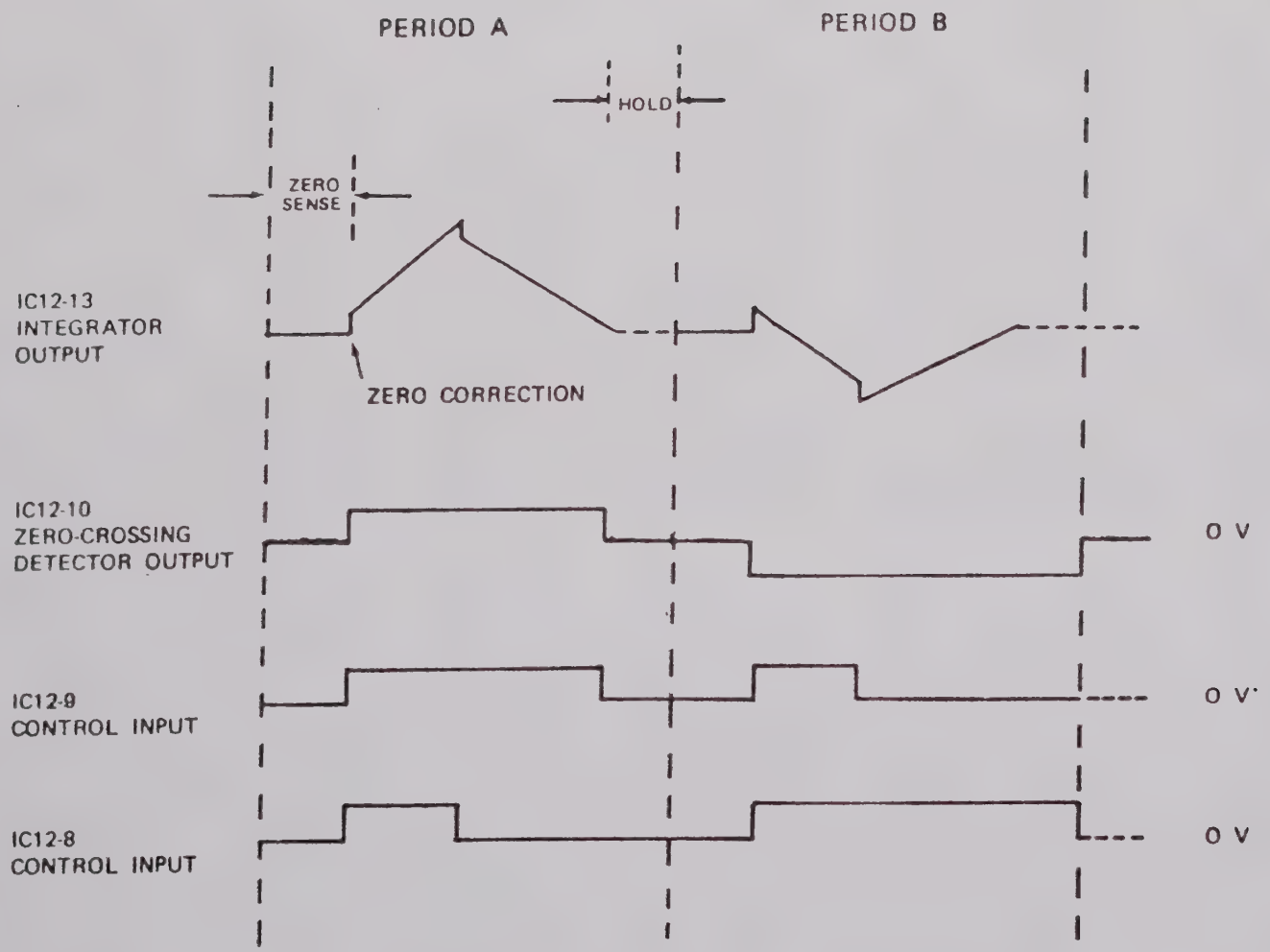


Figure 4-2, Model 4500
AID Converter Timing Diagram
for (A) positive input and (B) negative input.

4-18 (Continued)
polarity are now displayed.

4-19 LED DISPLAY

4-20 The display is produced by a scanning process, with each LED indicator being switched on and off at 1 KHz rate. While no two indicators are turned on simultaneously, the 1 KHz switching rate makes them all appear to be on continuously.

4-21 The 1 KHz pulse train used to switch the indicators is derived by dividing the 200 KHz oscillator output, set by the precision timer input applied to IC13-17. The switching outputs are applied to indicator drivers Q2-Q6 via IC13-2 to -6, as shown in Figure 4-3.

4-22 The BCD count corresponding to the least significant digit is shifted out of the buffer register, decoded into seven-segment format, and appears at IC13-7 to -14 at the time IC13-2 enables Q4, causing the LED indicator to display the count. This shifting and decoding process is repeated for the 10^2, 10^3, 10^4 and finally the most significant digit as Q3, Q2, Q5 and Q6 are sequentially enabled. The result is a display that appears continuous to the human eye.

4-23 INPUT ATTENUATOR

4-24 When either the 200MV or 2V range is selected the unknown input voltage is not attenuated. Instead, it is applied via the Function and Range switches directly to the A/D Converter input IC12-1 and -2. If the 200MV range is selected, however, it applies +8 volts to IC7-12 and -13. This sets the A/D Converter gain to maximum and reduces the reference voltage by a factor of 10. (Since IC7-1 and -2 are effectively open and IC7-3 and -4 are effectively closed the reference voltage is applied to IC12-4 from the arm of R19.)

4-25 When the 2V range is selected the +8 volts is removed from IC7-12 and -13 and applied to IC7-5 instead. Consequently the A/D Converter gain is reduced by a factor of 10 and the reference voltage is increased by the same factor, since it is not to IC12-4 from the arm of R21 instead of R19.

4-26 When either the 20V or 200V range is selected the input voltage is applied to a divider consisting of R47, 48 and 49. The output of the divider is the junction of R47 and R49, and the unknown input is attenuated by a factor of 100:1. On the 20V range IC7 sets the A/D Converter high; on the 200V range it is reduced as it was on the 2V range. On the 2KV or 100KV range the attenuator comprises R47-52, providing 10,000:1 attenuation. The A/D Converter gain is again selected by IC7, as it was on the lower range pairs.

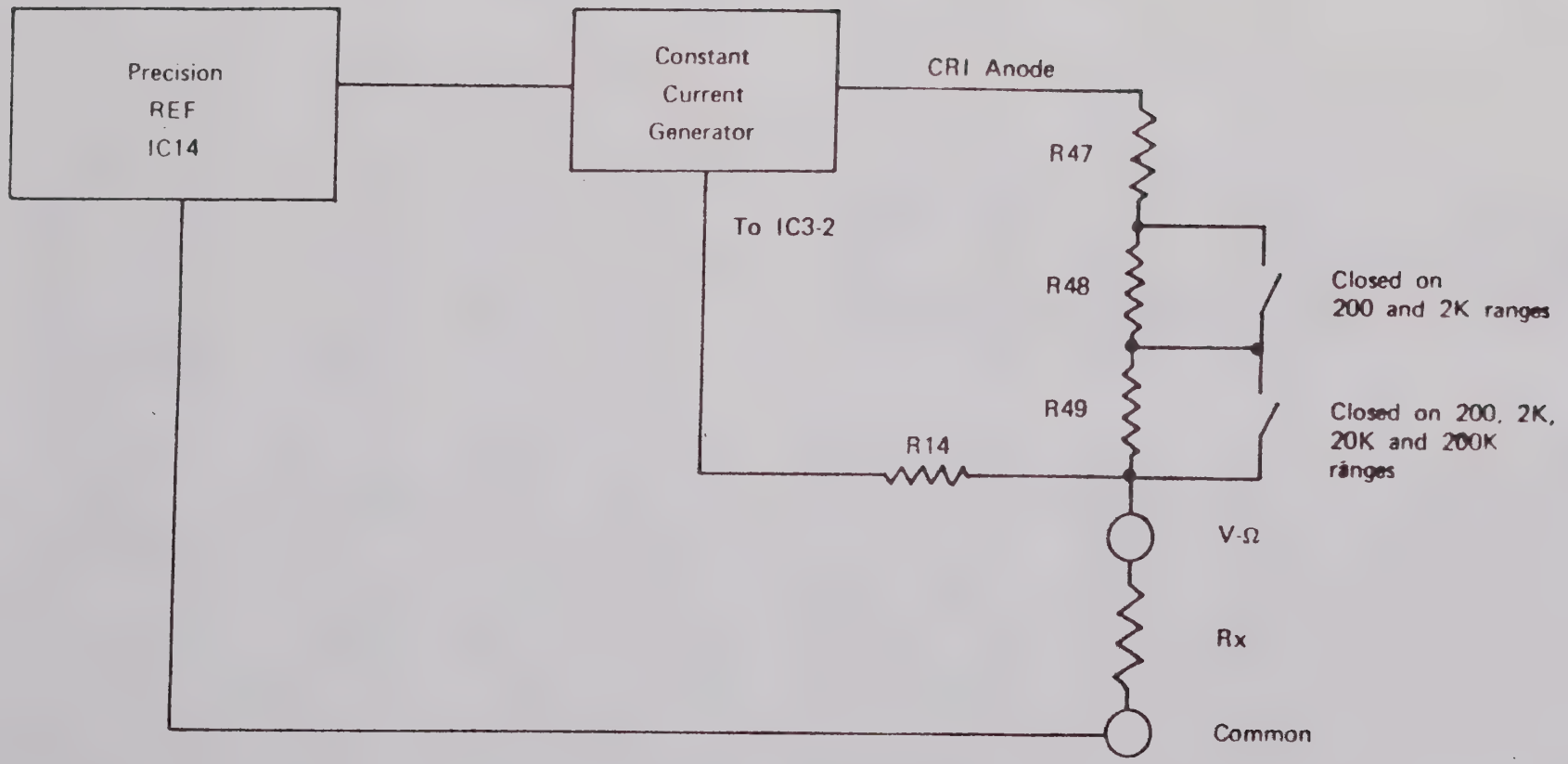


Figure 4-3. Ohms/DC Converter Block Diagram.
Range selectors set alternator ratio and output of
constant current generator (so described in Subsection 4-35).

4-27 AC/DC CONVERTER

4-28 The Model 4500 is available with the standard "averaging" AC Converter, a true RMS AC Converter (Option TRMS) or both. Consequently the Model 4500 can be used to accurately measure either sinusoidal or non-sinusoidal AC voltages.

4-29 The standard AC Converter consists of IC8, IC9, IC10, CR8 and CR9 and associated components.

The AC input is coupled from the attenuator through C18 to IC8-3. On the 200MV, 20V and 2KV ranges R23 is grounded via IC7-8 and -9 for maximum gain; on all other ranges R23 is ungrounded and IC8 gain is reduced by 10:1.

4-30 The output at IC8-6 is coupled through C9 and R32 to IC9. CR8 and CR9 provide feedback around IC9 via R33 and R34, and the rectified output is coupled from CR9 and filtered by R35 and C10. The DC output at IC10-6 is proportional to the ACrms input (for sinusoidal voltages only) and is coupled via the AC Function switch to the A/D Converter input at IC12-1.

4-31 The Option TRMS AC Converter comprises IC4 and associated components; its input at IC4-1 is coupled from IC8-6 via C9, R7 (gain trimmer) and C6. IC4 internal circuitry consists of a voltage-to-current converter, a squarer/divider, a current averager and a source follower that produces the output at IC4-6. C4 and C5 set the current averaging period and also determine the ripple level and settling time of the converter. C3 filters the current output at IC4-8 before it is applied to the output buffer at input terminal IC4-7. R69 is the zero offset adjustment.

4-32 The AC voltage input at IC4-1 is converted to a proportional AC current which is squared, averaged and divided to provide an RMS current output at IC4-8. This output drives the buffer input at IC4-7 to produce a DC voltage equivalent to the true RMS AC input. The voltage is coupled via the AC Function switch to the A/D Converter input IC12-1 and -2 for measurement.

4-33 INPUT ATTENUATOR

4-34 On the AC Function the range attenuator switching is identical to that on the DC Function (described in Sub-Section 4-23) with one exception; on AC the DC reference voltage and A/D Converter gain are held constant for all ranges by IC7-12 and IC7-5 via the AC Function switch. The AC Converter gain, however, is alternately set high and low via the Range Selector switches.

4-35 OHMS/DC CONVERTER

4-36 The Ohms/DC Converter is a constant-current generator

4-36 (Continued)
which is connected to the unknown resistance Rx. The voltage drop across Rx is proportional to its resistance, and Erx is measured by the A/D Converter and displayed as the value of Rx.

4-37 The constant-current generator consists of IC1, IC2, IC3, Q1, CR1 and associated components. Its input is derived from the precision reference IC14 via the arm of R19 and applied at IC1-3. The output at IC1-6 is applied to floating differential amplifier input IC2-3. IC2-6 drives IC3, which is the first section of the constant-current output stage. The output at IC2-6 is accurately controlled by feedback resistors R3 and R13. Network R5-C2 provides high-frequency stabilization.

4-38 The constant current originates at the anode of CR1. The amount of current through Rx is determined by the range selected. On the 200 or 2K range the feedback from the junction of R47 and Rx sets the current to 1 ma; selecting the 20K or 200K range connects R48 in series with R47 and reduces the current to 10 micro-amperes. On the 2M or 20M range R47, R48 and R49 are connected in series and the current through Rx is reduced to 100 na.

4-39 When the 200, 20K or 2M range is selected +8 volts is applied to IC7-12 and -13 via the AC Function switch contacts. This sets the A/D Converter gain high and reduces the reference voltage applied at IC12-4. When the 2K, 200K or 10M range is selected the +8 volts is removed from IC7-1 and -13 and applied to IC7-5. The A/D Converter gain is reduced and the reference voltage is increased, each by a factor of 10.

4-40 ELECTRICAL OUTPUTS

4-41 The Model 4500 provides electrical outputs in BCD format that are directly compatible with the Valhalla Scientific Model 1248 Digital Comparator. These outputs are developed by decoding the 7-segment outputs of IC13 and applying them to the inputs of a seven segment to BCD connector.

4-42 The BCD outputs and the outputs from Q2-Q5 appear at an Amphenol 57-40500 connector at the rear of the Model 4500. Connections are shown in Figure 4-4. When the Model 4500 and the Model 1248 are interconnected the BCD outputs are connected in parallel to the 1's, 10's, 100's and 1,000's decades of the Model 1248. The inputs from Q2-Q6 sequentially enable each decade, clocking the corresponding BCD data into the comparison circuits of the Model 1248.

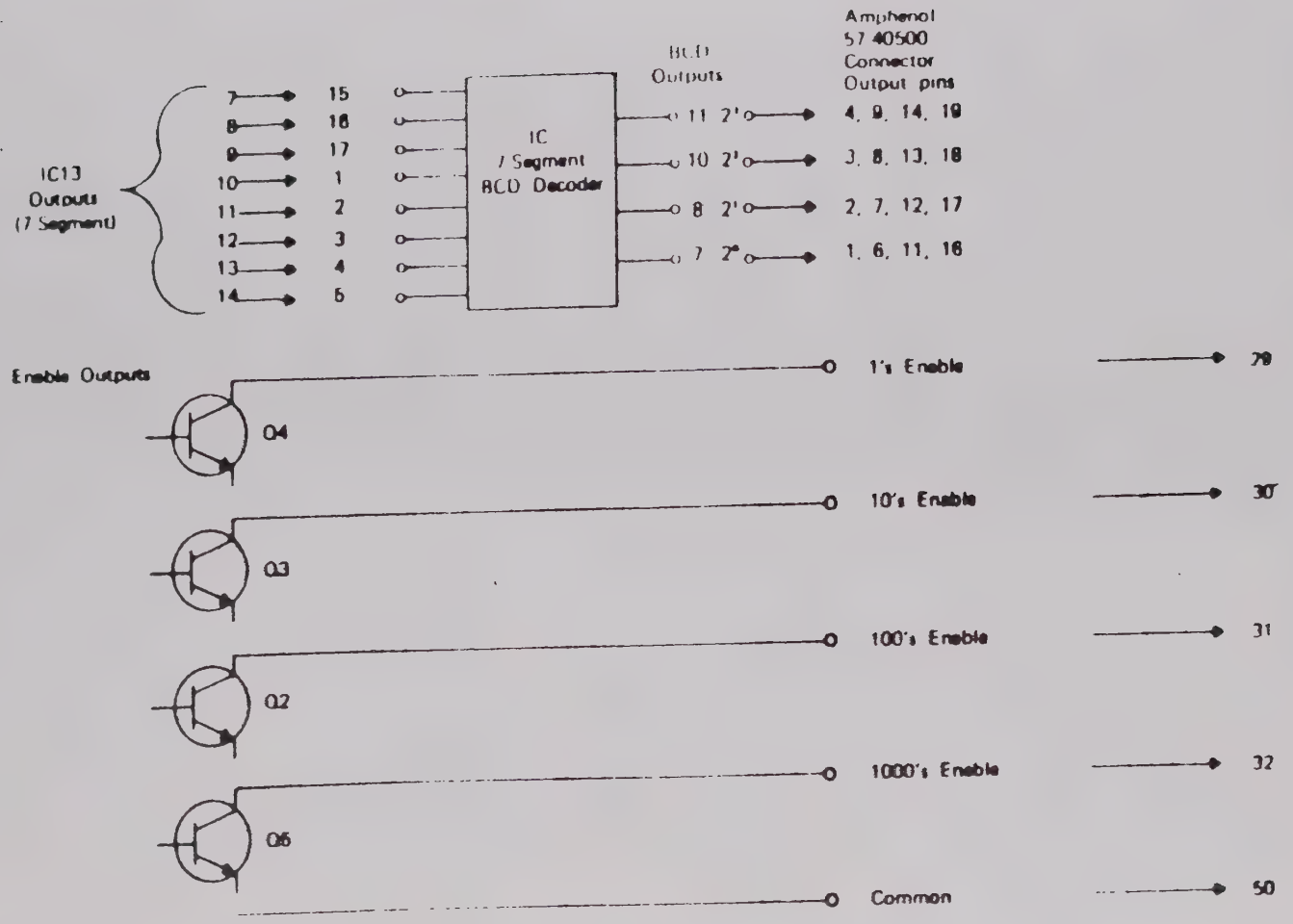


Figure 4-4. Electrical Output Connections of Model 4600

SECTION V

MAINTENANCE

5-1 INTRODUCTION

5-2 This section contains maintenance information for the Valhalla Scientific Model 4500 Digital Multimeter. Included are a test equipment list and calibration procedures.

5-3 REQUIRED TEST EQUIPMENT

5-4

EQUIPMENT	PERFORMANCE SPECIFICATIONS
DC Voltage Standard	±0.003% accuracy, 0.1 to 200V; ±0.01% accuracy, 200 to 1KV.
AC Voltage Calibrator	±0.02% accuracy, 0.1 to 100Vrms at 1KHz.
Precision Resistor	±0.005%, 1 K ohm.
Oscilloscope	50mVDC/CM sensitivity.
Frequency Counter	±0.01%, 10 Hz-1 MHz.

5-5 CALIBRATION PROCEDURE

5-6 The Model 4500 should be calibrated periodically to insure continuing accuracy; it should also be calibrated if an accuracy-determining component is repaired or replaced.

Turn on the instrument at least five minutes before beginning calibration.

5-7 DC CALIBRATION

1. Select DC Function and 200mV range.
2. Connect the counter to IC11-3 and adjust R53 for a 200 KHz reading in the counter display. Remove the counter connections.
3. Short the Model 4500 V-Ohms and Common jacks. Adjust R75 for 00.00 in the display.
4. Apply +100 mVDC between V-Ohms and Common. Adjust R21 for 100.00 in the display.
5. Select DC Function and the 2V range. Apply +1 VDC between V-Ohm and Common. Adjust R19 for 1.000 in the display.
6. Select DC Function and the 2KV range. Apply 1 KV between the High Voltage and Common jacks. Adjust R51 for 1000.0 in the display. This completes DC calibration.

5-8 OHMS CALIBRATION

5-9 OHM CONVERTER

1. Select Ohm Function and the 2K range.
2. Connect the 1K precision resistor from V-Ohm to Common.
3. Adjust R10 for 1.0000 in the display.

5-10 AC CALIBRATION

NOTE

DC Calibration steps 1-6 must be performed to insure specified AC accuracy.

5-11 AVERAGING AC CONVERTER

1. Select the AC Function and the 200MV range. Short V-Ohm and Common. Adjust R26 for 00.00 in the display.
2. Apply 100mVACrms at 1 KHz between the V-Ohm and Common. Adjust R23 for 100.00 in the display.
3. Select the 2V range. Apply 1 VACrms at 1 KHz between V-Ohm and Common. Adjust R36 for 1.0000.

5-12 OPTION TRMS CONVERTER

1. Select the AC Function and the 2V range. Apply 100 mVACrms at 1 KHz between V-Ohm and Common. Adjust R69 for .1000 in the display.
2. Increase the input voltage of (7) to 1 volt. Adjust R7 for 1.0000 in the display.
3. Reduce the input voltage to 100 mv and select the 200MV range. Adjust R23 for 100.00 in the display.

5-13 The following step is performed to complete calibration of both the Standard and TRMS Converters.

1. Select the 200V range. Apply 100 VACrms at 10 KHz between V-Ohm and Common. Adjust C16 for 100.00 in the display.

5-14 TROUBLESHOOTING

5-15 Apparent difficulties are sometimes merely misinterpretations of specifications. In other cases they may be caused by excessive input noise, either superimposed on the input signal or radiated to the input leads. In any case, the user should make every effort to assure himself that the instrument is truly malfunctioning before attempting repairs.

5-16 Frequently a digital multimeter malfunction will only be evident on a single range or function. At other times it will be apparent on every range and function. When an instrument is totally inoperative, examine the power supply. If it malfunctions on all functions, check for problems in the common sections of the instrument; that is, the power supplies, the A/D Converter or the digital processor control circuitry.

5-17 Cycling the instrument through each of its functions and ranges while observing the display will often indicate exactly which section of the instrument is malfunctioning. Refer to the diagrams of Section IV, and the accompanying circuit descriptions, if unfamiliar with the operating principles of any part of the instrument. The clues obtained, combined with a working knowledge of the circuits should allow correction of any malfunction.

5-18 POWER SUPPLIES

5-19 The power transformer delivers AC to two DC supplies. One consists of CR6, CR7, and C13. It produces +5 volts.

5-20 The second supply consists of CR2-5 and C11-12. These components comprise a bridge rectifier which develops and filters $\pm$12 volts DC. IC5 and IC6 are regulators which reduce these voltages to a nominal $\pm$8 volts.

5-21 Option 45B consists of a rechargeable sealed battery supply and a DC/DC Converter, the latter comprising IC1, IC2, Q1, Q2, C1 and a transformer. When the Power switch is ON, the battery is connected from the center tap of the transformer to the emitters of Q1 and Q2. IC1 and IC2, dual flip-flops, divide the 200 KHz output of IC11-3. The resulting 12.5 KHz pulses alternately switch Q1 and Q2 on and off. The resulting conduction of Q1 and Q2 produce AC pulses in the transformer primary. These pulses induce an AC voltage across the transformer secondary. This AC voltage is rectified by the bridge comprising CR1-CR4 and is filtered by C2 and C3. The $\pm$12 volt output is regulated by IC5 and IC6 to produce the $\pm$8-volt supply. The battery itself produces the +6 volts.

5-22 When the instrument line cord is plugged into an AC power source, Option 45B operates essentially in a no-load condition and the battery charges, even when the Power switch is OFF.

OPTION "45B" FIELD RETROFIT INSTRUCTIONS

STEP NO.1
Remove four screws from bottom of unit and carefully separate top and bottom lids. Both the front and rear panels should remain with top lid.

STEP NO. 2
Place top lid on work surface with P.C. board facing up.

STEP NO.3
Dyke all small mold marks and one stand-off in order to allow flush fit of battery assembly in back right hand corner of the unit. Leave the three stand-offs which coincide with the holes on the battery assembly P.C. board.

STEP NO.4
Place battery assembly P.C. board down in the right rear vacant area of the inverted lid. (Stand-offs should protrude thru the holes in P.C. board.)

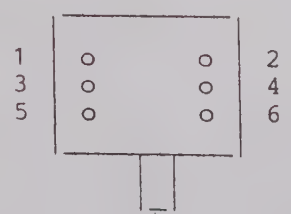
STEP NO.5
Solder wires from battery assembly to main board in a pt. to pt. manner. Be careful not to short batteries.

STEP NO.6
Insert solder in K-74 and 500 Ohm pot in R76. (Both are located on extreme left hand side of main PC Board.)

STEP NO.7
Check to insure pot is centered.

STEP NO.8
Drill out feed thru hole next to K74.

STEP NO.9
Short pins 1 and 3 from power off-on switch as they appear here.



This may be accomplished by bending them together and soldering.

NOTE: Batteries will now charge in the power on or power off mode and last 6 hours on a full charge.

Valhalla Scientific Inc. | **PARTS LIST** | DIGITAL H. V. MULTIMETER | MODEL 4500 | DWG NO | REV E

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N				REMARKS
1	C2	2-10004	Cap Cerm .02 uf	56289	5GAS-S20	1					
2	C3	2-30000	Cap Tan 4.7 uf/10V	05397	T390B475M16AS	1					
3	C4	2-30008	Cap Tan 6.8uf/10V	05397	T390B685M010AS	1					
4	C5	2-20009	Cap Mica 470Pf	81349	CM05FD471J03	1					
5	C7, 8, 9, 10, 36	2-30001	Cap Tan 10uf/10V	05397	T390B106M016AS	5					
6	C11, 12, 21	2-40001	Cap Elect 250uf/25V	14655	BR250-25	3					
7	C13	2-40004	Cap Elect 2200uf/16	56289	16T2200	1					
8	C14, 20	2-80002	Cap Mylar 1 uf/50V	12406	Z5A105	2					
9	C15, 24	2-60004	Cap Paper .01uf	56289	418P10396K03	2					
10	C16	2-70000	Cap Var 12Pf	73899	VC58G	1					
11	C17	2-50000	Cap Poly .22uf	27556	PA2A224	1					
12	C18, 22	2-10000	Cap Cerm .005uf	56289	5GAD50	2					
13	C19	2-20008	Cap Mica 240Pf	81349	CM05FD241J03	1					
14	C23	2-60000	Cap Paper .0047uf	56289	225P47291	1					
15	C31, 33, 26	2-20013	Cap Mica 100Pf	81349	CM05FD101J03	3					
16	C27	2-10012	Cap Cerm .02uf/1KV	56289	5GAS20	1					
17	C28, 29, 30, 1	2-10006	Cap Cerm .01uf	56289	5GAS10	4					
18	C6	2-30007	Cap Tan 2.2uf/10V	05397	T360B225M10AS	1					
19	C25	2-20015	Cap Mica 75Pf	81349	CM05FD750J03	1					
20	C32	2-20007	Cap Mica 150Pf	81349	CM05FD151J03	1					
21	C34	2-20006	Cap Mica 3Pf	81349	CM05FD200J03	1					
22	C35	2-20014	Cap Mica 20Pf	81349	CM05FD200J03	1					
23											

NOTES:

Valhalla Scientific Inc.	PARTS LIST	DIGITAL H. V. MULTIMETER	MODEL 4500	DWG NO	REV E

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
24	CR1	3-20004	Diode	07263	IN4004	1					
25	CR2-7	3-20002	Diode Rect	07263	IN4001	6					
26	CR8, 9	3-20000	Diode	07263	IN4148	2					
27											
28	DS1	5-01020	LED ± Display	28480	QDSP-3789	1					
29	DS2-5	5-01010	LED 0-9 Display	28480	5082-7650	4					
30											
31	IC1,2,3,8,9,10	3-30090	IC Op-Amp	27014	LF356N	6					
32	IC6	3-30085	IC Reg Pos	27014	78M08C	1					
33	IC5	3-30086	IC Reg Neg	27014	79M08C	1					
34	IC7	3-30023	IC Quad Switch	86684	CD4066BF	1					
35	IC11	3-30009	IC Timer	27014	NE555V	1					
36	IC12	3-30087	IC A/D Conv Analog	01295	TL500C	1					
37	IC13	3-30088	IC A/D Conv Digital	01295	TL502C	1					
38	IC14	3-30064	IC Reference	04713	MC1403	1					
39											
40	J1	5-10031	Banana Jack Wht	05276	1581-Wht	1					
41	J2	5-10032	Banana Jack Blk	05276	1581-Blk	1					
42	J3	5-10030	Banana Jack Red	05276	1581-Red	1					
43											
44	Q1	3-10015	Transistor H. V.	04713	MJE3439	1					
45	Q2-6	3-10010	Transistor PNP	04713	2N4402	5					
46	R29	1-10104	Res Fxd 150K 1%	81349	RN60C1503F	1					

NOTES:

Valhalla Scientific Inc.

PARTS LIST

DIGITAL H. V. MULTIMETER | MODEL 4500 | DWG NO | REV E

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
47	R46 R1,33,38,45,70,78	1-01061	Res Fxd 10K 1/4W 5%	81349	RC07GF103J	7					
48	R2,3,12,13	1-10049	Res Fxd 100K .1%	81349	RN60C1003B	4					
49	R4,5,76	1-01045	Res Fxd 2K 1/4W 5%	81349	RC07GF202J	3					
50	R6	1-01073	Res Fxd 47K 1/4W 5%	81349	RC07GF473J	1					
51	R7, 51	1-50004	Res Var 500 ohm	71450	X201R501	2					
52	R8	1-10085	Res Fxd 249 ohm 1%	81349	RN60C2490F	1					
53	R9	1-01093	Res Fxd 470K 1/4W 5%	81349	RC07GF474J	1					
54	R23	1-50000	Res Var 100 ohm	71450	X201R101	1					
55	R32, 34, 35	1-10008	Res Fxd 10K 1%	81349	RN60C1002F	3					
56	R14,54,27	1-01081	Res Fxd 100K 1/4 5%	81349	RC97GF104J	3					
57	R15	1-01033	Res Fxd 470 ohm 1/4W 5%	81349	RC07GF471J	1					
58	R16,28,60,67,68,71	1-01021	Res Fxd 100 ohm 1/4W 5%	81349	RC07GF101J	6					
59	R30		Factory select								
60	R19, 36	1-50002	Res Var 1K	71450	X201R102	2					
61	R20	1-10025	Res Fxd 90.9K 1%	81349	RN60C9092F	1					
62	R24	1-10105	Res Fxd 887 ohm 1%	81349	RN60C8870F	1					
63	R25	1-10017	Res Fxd 9.09K 1%	81349	RN60C9091F	1					
64	R26,53,69,10,74	1-50005	Res Var 50K	71450	X201R503	5					
65	R31	1-01128	Res Fxd 1000M 1/4W 5%	81349	RC07GF105J	1					
66	R37	1-10054	Res Fxd 22.1K 1%	81349	RN60C2212F	1					
67	R39	1-10012	Res Fxd 20K 1%	81349	RN60C2002F	1					
68	R40, 55-59	1-01041	Res Fxd 1K 1/4W 5%	81349	RC07GF102J	6					
69	R41	1-01060	Res Fxd 9.1K 1/4W 5%	81349	RC07GF912J	1					

NOTES:

Valhalla Scientific Inc.	PARTS LIST	DIGITAL H. V. MULTIMETER	MODEL 4500	DWG NO	REV E

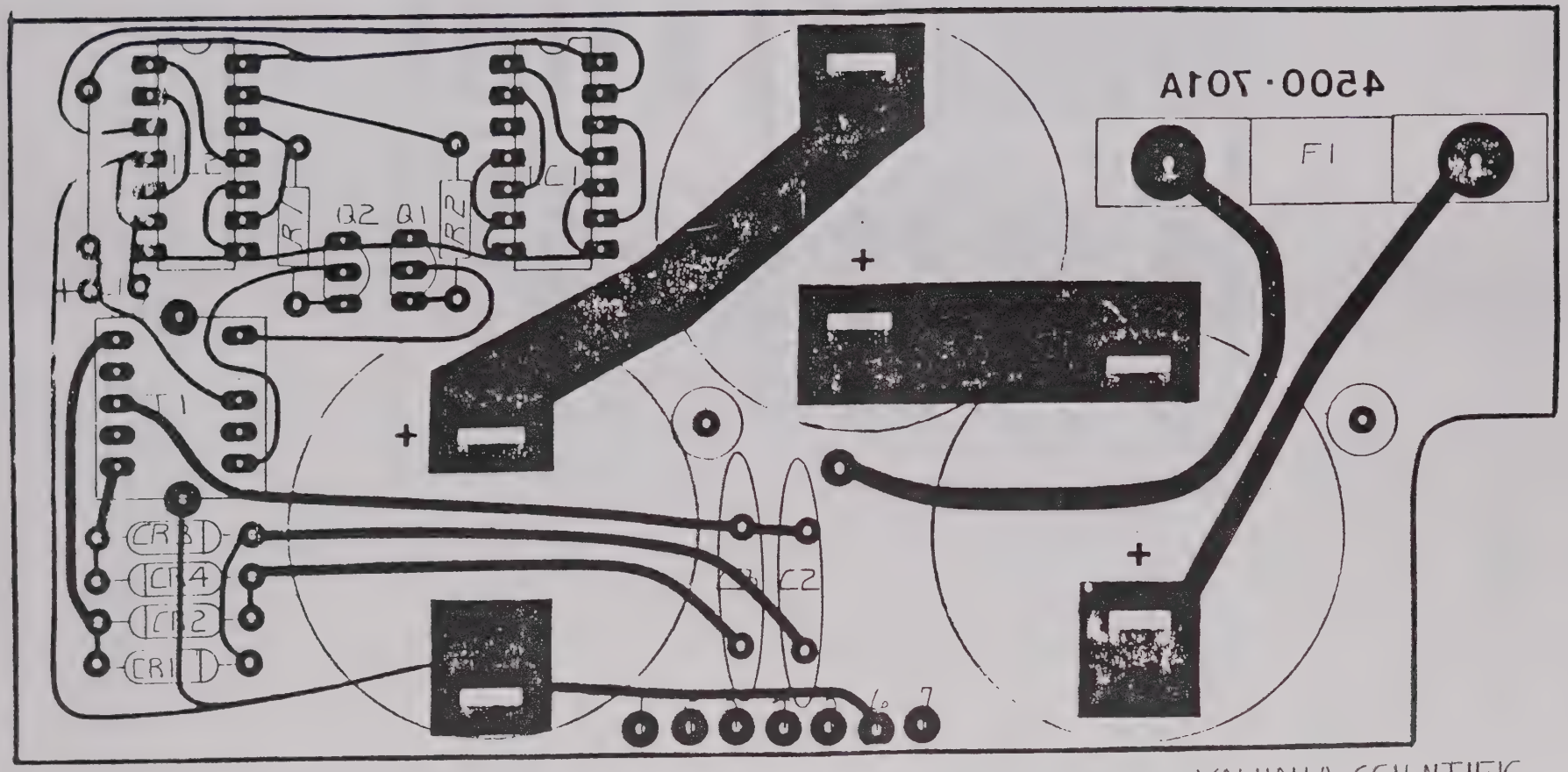
#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
70	R42	1-01068	Res Fxd 27K 1/4W 5%	81349	RC07GF273J	1					
71	R43	1-10015	Res Fxd 243K 1%	81349	RN60C2433F	1					
72	R44	1-10028	Res Fxd 24.9K 1%	81349	RN60C2492F	1					
73	R47	1-10090	Res Fxd 1K .1%	Caddock		1					
74	R48	1-10090	Res Fxd 99K .1%	Caddock		1					
75	R49	1-10090	Res Fxd 9.9M .1%	Caddock		1					
76	R50	1-10093	Res Fxd 100M 1%	Caddock		1					
77	R52	1-10073	Res Fxd 9.76K 1%	81349	RN60C9761F	1					
78											
79	R73	1-01007	Res Fxd 10 ohm 1/4W 5%	81349	RC07GF100J	1					
80	R74	0-01104	Res Fxd 2M 1/4W 5%	81349	RC07GF205J	1					
81	R22	1-10008	Res Fxd 10K 1%	81349	RN60C1002J	1					
82	R21	1-50007	Res Var 250 ohm	71450	X201R251	1					
83											
84	S1	5-03026	Push Button Function	71590	5-03026	1					
85	S2	5-03007	Toggle Switch	95146	MST-105D	1					
96											
97	T1	4-20019	Power Transformer	53504	4500-010	1					
98	E101	3-20022	Spark Gap 350V	Claire	CG2-350L	1					
99	E102	3-20023	Spark Gap 600V	Claire	CG@-600L	1					
100		4-30043	PC Board Main	53504	4500-700D	1					
101		4-30045	PC Board Display	53504	4500-702A	1					
102		4-10130	Chassis	aFrance	CH-250 Beige	1					

NOTE

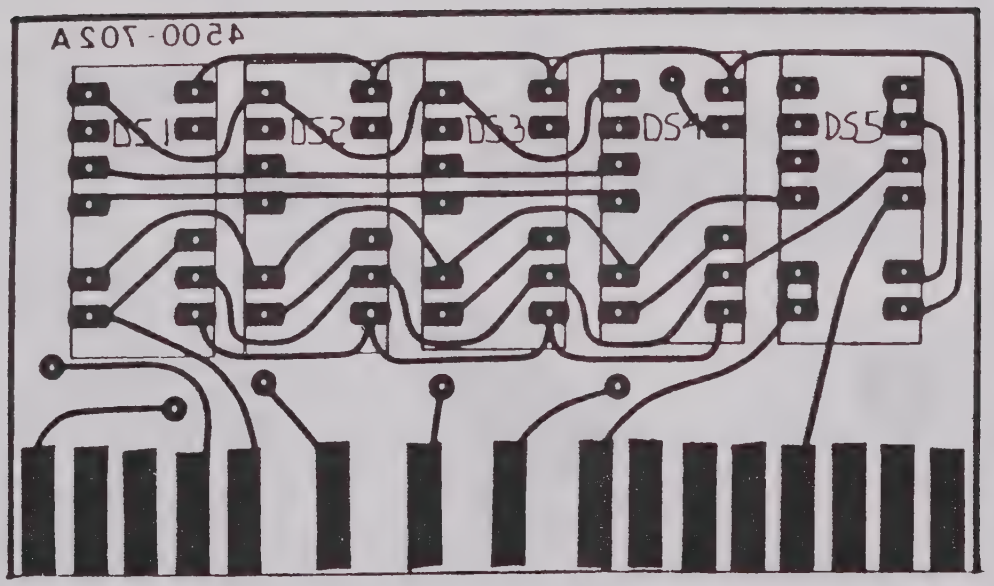
Valhalla Scientific Inc. | **PARTS LIST** | DIGITAL H. V. MULTIMETER | MODEL 4500 | DWG NO | REV E

#	REF DES	VALHALLA PART NO	DESCRIPTION	CODE IDENT	MFG PART NO	QTY. I	QTY. N	I	N		REMARKS
103		5-10363	Fuse Holder	75915	155120	1					
104		4-10166	Front Panel	53504	4500-200C	1					
105		4-10167	Rear Panel	53504	4500-201B	1					
106		5-10063	Power Conn	82389	EAC-301	1					
107		5-10007	Terminal		1300B	1					
108		4-10177	Shield	53504	4500-204	1					
109		5-10067	Power Cord	70903	17250	1					
110			6-32 x 3/8 pan head screws			4					
111			#4 self tapping screws			4					
112			6-32 Hex nuts								
113			#6 internal Star Washers			4					
114			Fuse 1/4A			1					
115			24 AWG Wire Red 12"			1					
116			24 AWG Wire Blk 20"			1					
117	IC4	3-30045	IC RMS to DC Conv	Analog Dev	AD536JH	1					
118			24 AWG Wire Grey 12"			1					

NOTES:



VALHALLA SCIENTIFIC
4500-601
ASSEMBLY DIAGRAM
REV. A



VALHALLA SCIENTIFIC
4500-602
ASSEMBLY DIAGRAM

REV. A

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

OPTIONAL RMS AC

OPTIONAL PRECISION REFERENCE

OPTIONAL 6V BATTERY

POWER ON

JUMPER FOR BATT OPERATION

HI VOLTAGE INPUT

10KV MAX

INPUT COMMON

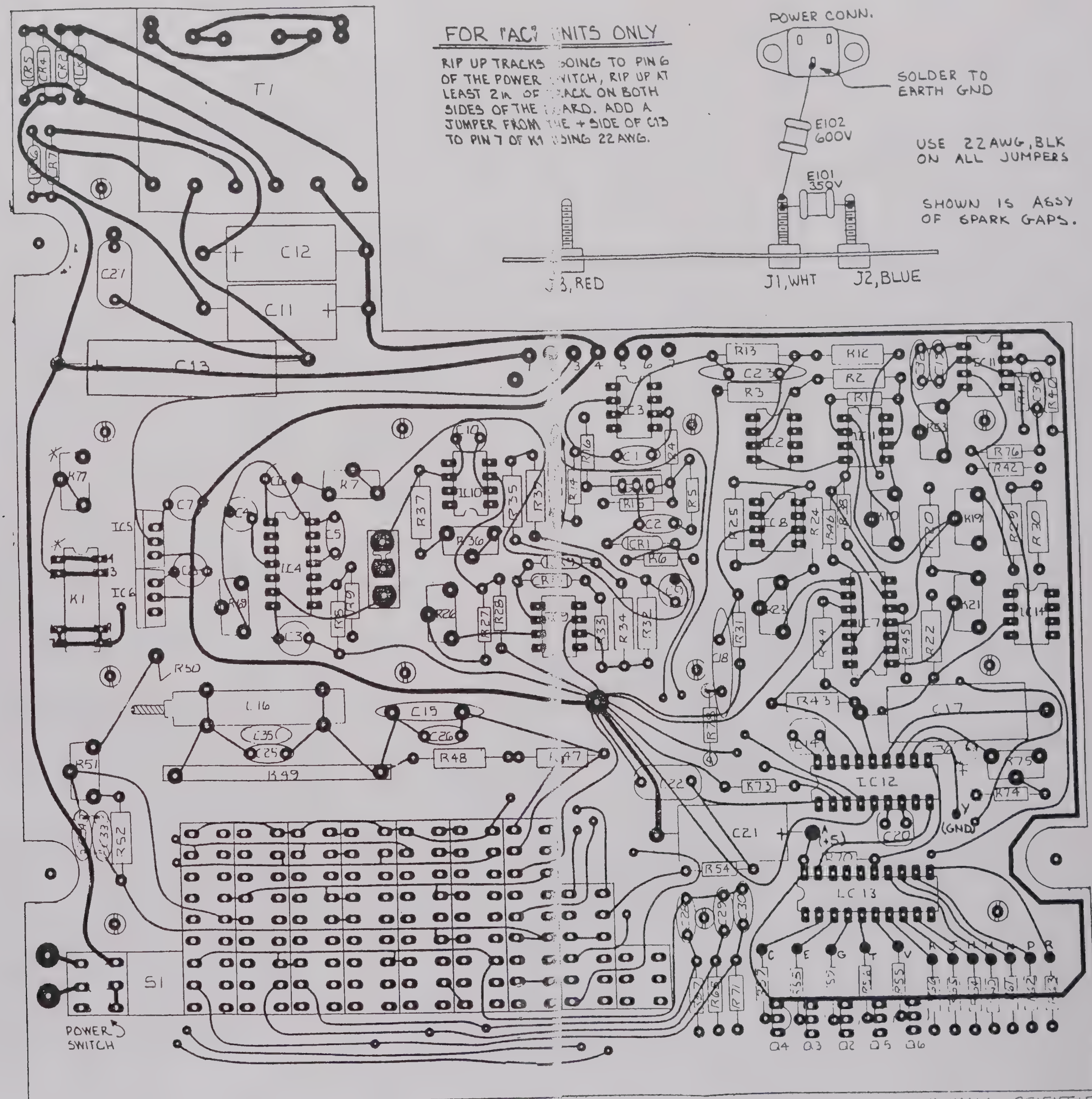
V-Ω INPUT

DIGITAL GND

ANALOG GND

POLARITY

MATERIAL	DRAWN	Valhalla Scientific Inc.	
	CHECKED	SAN DIEGO, CALIFORNIA	
	APPR	MODEL 4500 SCHEMATIC	
FINISH			
SCALE	CODE IDENT NO	SIZE D	DRAWING NO 4500-070 REV C
SHEET ___ OF ___			



FOR "AC" UNITS ONLY

RIP UP TRACKS GOING TO PIN 6 OF THE POWER SWITCH, RIP UP AT LEAST 2in OF TRACK ON BOTH SIDES OF THE BOARD. ADD A JUMPER FROM THE + SIDE OF C13 TO PIN 7 OF K1 USING 22 AWG.

USE 22 AWG, BLK ON ALL JUMPERS

SHOWN IS ASSY OF SPARK GAPS.

VALHALLA SCIENTIFIC
4500-600 ASSEMBLY DIA.
REV. E SHT. 4 OF 4

Federal Supply Codes for Manufacturers

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisburg, Pennsylvania

00853
Sangamo Electric Company
Pickens, South Carolina

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01255
Litton Industries, Inc.
Beverly Hills, California

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Dallas, Texas

01686
RCL Electronics Inc.
Manchester, New Hampshire

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Westwood, Maine

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Syracuse, New York

03797
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03911
Clairex Corp.
Mt. Vernon, New York

04009
Arrow Hart Inc.
Hartford, Connecticut

04217
Essex International Inc.
Anaheim, California

04222
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04713
Motorola Inc.
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05276
Pomona Electronics Co., Inc.
Pomona, California

05277
Westinghouse Electric Corp.
Youngwood, Pennsylvania

05397
Kemet, Union Carbide Corp.
New York, New York

05574
Viking Industries
Chatsworth, California

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Columbia, South Carolina

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06743
Clevite Corp.
Cleveland, Ohio

07088
Kelvin Electric Company
Van Nuys, California

07256
Silicon Transistor Corp.
Chelmsford, Massachusetts

07263
Fairchild Semiconductor
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Rochester, New York

07716
I R C Incorporated
Burlington, Iowa

07910
Teledyne Semiconductor
Hawthorne, California

08065
Accurate Rubber and Plastics Co.
San Diego, California

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Cleveland, Ohio

09026
Babcock Electronics Corp.
Costa Mesa, California

09214
G. E. Co. Semi-Conductor
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

11236
CTS of Berne
Berne, Indiana

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp.
Hicksville, New York

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12405
Hysol Corporation
El Monte, California

12406
Elpac, Incorporated
Fullerton, California

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13454
Texas Crystals
River Grove, Illinois

13511
Amphenol Cadre Div.
Los Gatos, California

13606
Use 56289
Sprague Electric Co.
Concord, New Hampshire

14099
Semtech Corp.
Newbury Park, California

14655
Cornell-Dublier Electronics
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14936
General Instrument Corp.
Hicksville, New York

15801
Fenwal Electronics Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors
Mountain View, California

15849
Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Cambridge, Maryland

16758
Delco Electronics
Kokomo, Indiana

17856
Siliconix, Inc.
Santa Clara, California

18324
Signetics Corp.
Sunnyvale, California

Federal Supply Codes for Manufacturers (cont.)

18612
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18722
R C A
Mountaintop, Pennsylvania

18927
GTE Sylvania Inc.
Titusville, Pennsylvania

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23936
Pamotor Div.
Burlingham, California

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Slatersville, Rhode Island

25684
Victoreen Instrument Co., Inc.
Oak Lawn, Illinois

27014
National Semiconductor Corp.
Santa Clara, California

27556
IMB Electronic Products
Santa Fe Springs, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
St. Paul, Minnesota

28480
Hewlett Packard Co.
Palo Alto, California

29083
Monsanto Co., Inc.
Santa Clara, California

29604
Stackpole Components Co
Raleigh, North Carolina

30323
Illinois Tool Works, Inc
Chicago, Illinois

30983
Electra/Midland
San Diego, California

32539
Mura Corp
Great Neck, New York

32897
Erie Technological Products, Inc.
Carlisle, Pennsylvania

32997
Bourns Inc.
Riverside, California

33173
General Electric Co.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
P.R. Mallory & Co., Inc.
Indianapolis, Indiana

43543
Nytronics Inc.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co
Springfield, Illinois

53504
Valhalla Scientific, Inc
San Diego, California

54294
Cutler-Hammer Inc
Selma, North Carolina

55026
Simpson Electric Co.
Elgin, Illinois

56289
Sprague Electric Co
North Adams, Massachusetts

58474
Superior Electric Co
Bristol, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

65092
Weston Instruments Inc.
Newark, New Jersey

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71279
Cambridge Thermionic Corp.
Cambridge, Massachusetts

71400
Bussmann Mfg.
Saint Louis, Missoun

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Brooklyn, New York

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Bechman Instrument Inc.
Helipot Division
Fullerton, California

73445
Amperex Electronic Corp.
Hicksville, New York

73734
Federal Screw Products, Inc
Chicago, Illinois

73899
JFD Electronics Co.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74276
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74970
Johnson E.F., Co
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76055
Mallory Controls
Frankfort, Indiana

76493
J.W. Miller Company
Los Angeles, California

76854
Oak Industries Inc.
Crystal Lake, Illinois

77342
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp.
Cleveland, Ohio

80031
Electro-Midland Corp.
Mepco Div.
Nornstown, New Jersey

56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

81073
Grayhill, Inc.
La Grange, Illinois

Federal Supply Codes for Manufacturers (cont.)

81095
Triad Transformer Corp.
Venice, California

81312
Winchester Electronics
Div. of Litton Industries Inc
Oakville, Connecticut

81483
International Rectifier Corp
Los Angeles, California

81741
Chicago Lock Co.
Chicago, Illinois

82389
Switchcraft Inc
Chicago, Illinois

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div
Pawtucket, Rhode Island

83003
Varo Inc
Garland, Texas

83298
Bendix Corp.
Eatontown, New Jersey

83330
Herman H. Smith, Inc
Brooklyn, New York

83594
Burroughs Corp.
Plainfield, New Jersey

83740
Union Carbide Corp
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
Ogallala, Nebraska

84613
Fuse Indicator Corp
Rockville, Maryland

84682
Essex International Inc.
Peabody, Massachusetts

86684
Radio Corp. of America
Harrison, New Jersey

88219
Gould Inc
Trenton, New Jersey

88245
Litton Systems Inc
Useco Div
Van Nuys, California

88419
Cornell-Dubilier Electronic Div
Fuquay-Varian, North Carolina

89730
G.E. Co
Newark, New Jersey

90201
Mallory Capacitor Co.
Indianapolis, Indiana

56365
Square D Co.
Chicago, Illinois

90303
Mallory Battery Co
Tarrytown, New York

91094
Essex International Inc.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91929
Honeywell Inc.
Micro Switch Div
Freeport, Illinois

92194
Alpha Wire Corp
Elizabeth, New Jersey

93332
Sylvania Electric Products
Woburn, Massachusetts

94988
Wagner Electric Corp
Tung-Sol Div
Newark, New Jersey

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95275
Vitramon Inc
Bridgeport, Connecticut

95303
RCA Corp
Receiving Tube Div
Cincinnati, Ohio

95348
Gordo's Corp
Bloomfield, New Jersey

95712
Bendix Corp.
Franklin, Indiana

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwalt Corp
SS White Industrial Products Div
Piscataway, New Jersey

98278
Malco A. Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98978
IERC
Burbank, California

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Monrovia, California

99779
Use 29587
Bunker-Ramo Corp.
Landsdowne, Pennsylvania

99942
Centrelab Semiconductor
El Monte, California